TEMPORAL AND SPATIAL ZONATION OF THE DEMERSAL TRAWL FAUNA OF THE CENTRAL GREAT BARRIER REEF

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Management needs for zonation of the central Great Barrier Reef Marine Park by user activity prompted a study of the demersal trawl fauna from a range of sites. Cluster analysis revealed three distinct site assemblages: 'coastal', 'inshore', and 'inter-reef', characterized by the conspicuous abundance of some species and the absence of other species. The location of these assemblages was related to water depth, sediment particle size composition and distance offshore but could not be explained by the distribution of fishing effort. Some sites, intermediate in location between these assemblages, were assigned to a 'transitional' assemblage in which sites changed affiliation temporally.
□*trawl bycatch, demersal, reef, zonation, Great Barrier Reef.*

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The inter-reef regions of the Great Barrier Reef (GBR) are the focus of an expanding prawn trawl fishery. This is a result of economic pressures on the heavily capitalized fleet to increase landings and the number of species and stocks exploited. All the fisheries of the GBR are subject to operating limitations and regulations imposed by the Great Barrier Reef Marine Park Authority. Although the inner shelf areas have been trawled extensively by commercial fishermen, our knowledge of the animal assemblages that inhabit these grounds is still relatively poor. As a consequence, present zoning of the reef for different uses by management authorities has been based more on socio-economic considerations than on biological ones.

Although Frankel (1978) listed some 4,500 literature citations from the GBR region, most of these dealt with the shallower coral reef environs. Only recently have studies dealing with the structure of tropical trawled communities of the Indo-pacific appeared: in the Gulf of Papua (Kailola and Wilson, 1978; Watson, 1984), the northern Gulf of Carpentaria (Liu *et al.*, 1978), and the southern Gulf of Carpentaria (Rainer and Munro, 1982). In unpublished reports Goeden and Cannon (1980) described macrofauna from a small trawl grid across the GBR in the Cairns region, and Birtles *et al.* (1982) described fauna from a single trawl transect from the coast to the shelf edge off Townsville. Cannon *et al.* (1987) represent the first attempt made to describe community zonation of the inter-reef regions on a large scale.

Rainer and Munro (1982) reported on the community zonation of the southern Gulf of Carpentaria, but restricted their analysis to fishes and cephalopods. Cannon *et al.* (1987) included most of the major macrofaunal groups (fishes, molluscs, echinoderms, crustaceans, cnidarians, and sponges) in their description of zonation patterns along the GBR. They showed that the broader taxonomic data set improved resolution of community types and suggested that some of the less mobile taxa might be good indicators of the effects of any increased trawling effort in the future. Both of these studies used non-replicated samples collected from a large number of sites so that examination of small scale spatial differences and the effects of seasonal variation was impossible.

The objective of our work was to provide baseline data sets that characterize inter-reef communities and their seasonality in areas recently exposed to fishing. An understanding of the inter-reef communities will allow assessment of potential problems caused by commercial trawling and allow construction of longer term management strategies for the Great Barrier Reef Marine Park.

MATERIALS AND METHODS

Twenty trawl sites were chosen in conjunction with a study of an existing prawn fishery on Queensland's continental shelf between 18°S and 20°S latitude (Fig. 1). They were positioned to provide a range of water depth, distance from shore, and to include sites throughout the range of the prawn fishery.

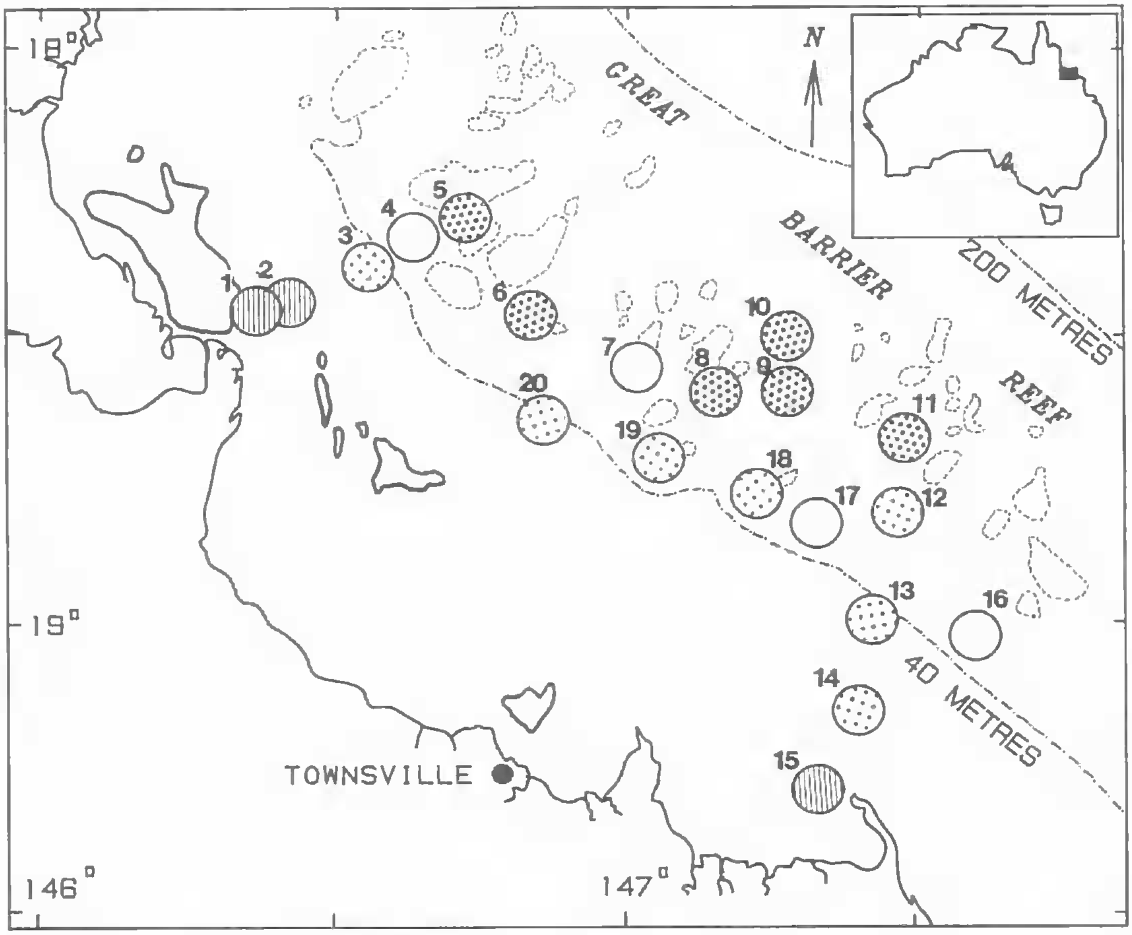

FIG. 1. Location of sampling sites showing their site assemblage affiliations: 'A' - coastal (strips), 'B' - inshore (small dots), 'C' - inter-reef (large dots), and transitional (clear).

Samples were obtained by trawling on consecutive nights, at or around the time of the new moon from a 20 m vessel each month from January 1985 through December 1985. Most sites were sampled 12 times (a single tow per site monthly) except for sites missed in February and March due to bad weather. Two 'Florida Flyer' nets, each with a 12 m headline length, were towed along the bottom following the depth contour for 30 minutes at approximately 6 km/hr. The samples were obtained from the starboard net which was constructed of 27 ply polypropylene, 50 mm stretch mesh which is standard for commercial trawlers in the northern prawn fishery. The port net had 40 mm mesh and fauna taken from it were not used in the present study except on the rare occasions (less than 3% of samples) when the starboard net failed.

Large, difficult-to-handle elements such as sponges, sea snakes, and large elasmobranchs such as stingrays and shovel-nose sharks, were noted and discarded. The total catch from the starboard net was weighed and a random subsample of approximately 10 kg was taken and rapidly frozen. When thawed in the laboratory, all fishes, crustaceans, echinoderms, and molluscs were identified to species level. Taxa which could not be identified easily were forwarded to the Queensland Museum. All identifications of fishes, crustaceans and molluscs were eventually confirmed by the Queensland Museum. Taxa identifications were outlined in Jones and Derbyshire (1988).

Sediment samples of approximately one litre were collected from each trawl sampling site once during December 1985 using a Smith-McIntyre grab. In the laboratory , these samples were wet sieved into fractions with the following particle sizes: over 2mm, 2-1mm, 1-0.5mm, 0.5-0.25mm, 0.25-0.125mm, 0.125-0.063mm, and under 0.063mm.

Records of fishing effort were extracted from voluntary logbooks issued to 40 to 50 fishermen trawling between 18°S and 21°S. The records were expressed as hours trawled and catch landed within defined six by six minute areas. Average monthly effort in fishing hours per grid area from areas containing our trawl sites were used as a measure of fishing effort expended in the vicinity of our sample sites.

The SPSS package was used for the preliminary analyses of data and to calculate species frequencies. Species present in fewer than 5% of samples or whose identities were in doubt were omitted from subsequent analysis. For the remaining species, the numbers of individuals were standardized as the log base 10 of the total number caught in the starboard net per hour of trawling. These numbers are referred to as abundances. A commercial software package, CLUSTAN (University of Edinburgh, Scotland, 1978), was used to cluster trawl sites using abundance. The clusters of sites produced are referred to as site assemblages. Quasi-metric Bray-Curtis measures were calculated (Bray and Curtis, 1957) and a hierarchic fusion of the matrix was performed using Ward's method, also known as Error Sum of Squares (Ward, 1963). This combination of measure computation and fusion method was considered to yield good results (Abel and Williams, 1985) despite the traditional restriction of Ward's method to strictly metric measures. For comparison, other distance measures such as squared euclidean distance and average distance were used with Ward's, Lance-Williams' flexible Beta, and the Group Average methods, with similar results.

CLUSTAN was also used to produce dendrograms and diagnostics for each site assemblage. An assemblage was characterized by two groups of species: those species which were consistently abundant compared to the other assemblages (referred to as inherent); and those which were conspicuously absent while being generally abundant (consistently greater than 10 individuals) in other clusters (referred to as missing). CLUSTAN was also used to cluster sites based on their sediment particle size composition.

RESULTS

A catch of about 8 tonnes was landed. Approximately a quarter of this was sorted and counted. Included were 450 taxa from nine phyla, 13 classes, and 110 families. Only a very small proportion of the material (less than 4%) has commercial value. Fishes constituted 38%, and crustaceans 42% of the individual animals taken in the samples. No species were present in every sample taken during the entire sampling period and the vast majority were present in fewer than 50% of samples. About 70% of the biomass of the catch consisted of small (10-20 cm total length) fishes and the majority of the balance were small crustaceans.

Dendrograms of the monthly classification of sites revealed consistent site assemblages (Fig. 2). With the possible exception of March, when many sites were missed due to bad weather, the 20 sites grouped monthly into three site assemblages (denoted 'A' coastal, 'B' inshore, and 'C' inter-reef) at a dissimilarity level of approximately 0.75. Of these assemblages, 'B' and 'C' were consistently more similar, that is, they clustered together sooner in the analysis. Although the exact relationships between the sites changed from month to month, the overall classification was remarkably consistent and only a small number of sites changed their assemblage affiliations (Fig. 2). A 'transitional' site was defined as one which was a member of a single site assemblage for less than 70% of the monthly samples obtained from that site. Four sites were transitional: 4, 7, 16, and 17. If the occurrence within a single site assemblage is restricted to 60% then there were only two transitional sites: 4 and 7. All transitional sites shared their monthly affiliations between assemblages 'B' and 'C'. Table 1 lists the monthly classification of sites and the proportion of occurrences within assemblages 'A', 'B' and 'C', as well as those designated as transitional.

Locations of the sampling sites together with their appropriate site assemblages are shown in Fig. 1. The transitional sites, 4 and 7, had the weakest site assemblage affiliations and were geographically close to coral reef complexes, unlike transitional sites 16 and 17. Although sites 18 and 19 were also located close to coral reefs, they were both clustered with assemblage 'B' in 89% of the monthly samples.

The general distribution of site assemblages roughly parallels the coastline (Fig. 1). Sites 1, 2 and 15 ('A') can be considered as 'coastal'; sites 3, 12, 13, 14, 18, 19 and 20 ('B') as 'inshore', and sites 5, 6, 8, 9, 10 and 11 ('C') as 'inter- reef'. The transitional sites 4 and 7 were approximately equally divided between 'inshore' and 'inter-reef' assemblages. Transitional sites 16 and 17 were primarily 'B' or 'inshore' sites (Table 1).

Monthly lists of inherent species for each of the three site assemblages were sorted and the species

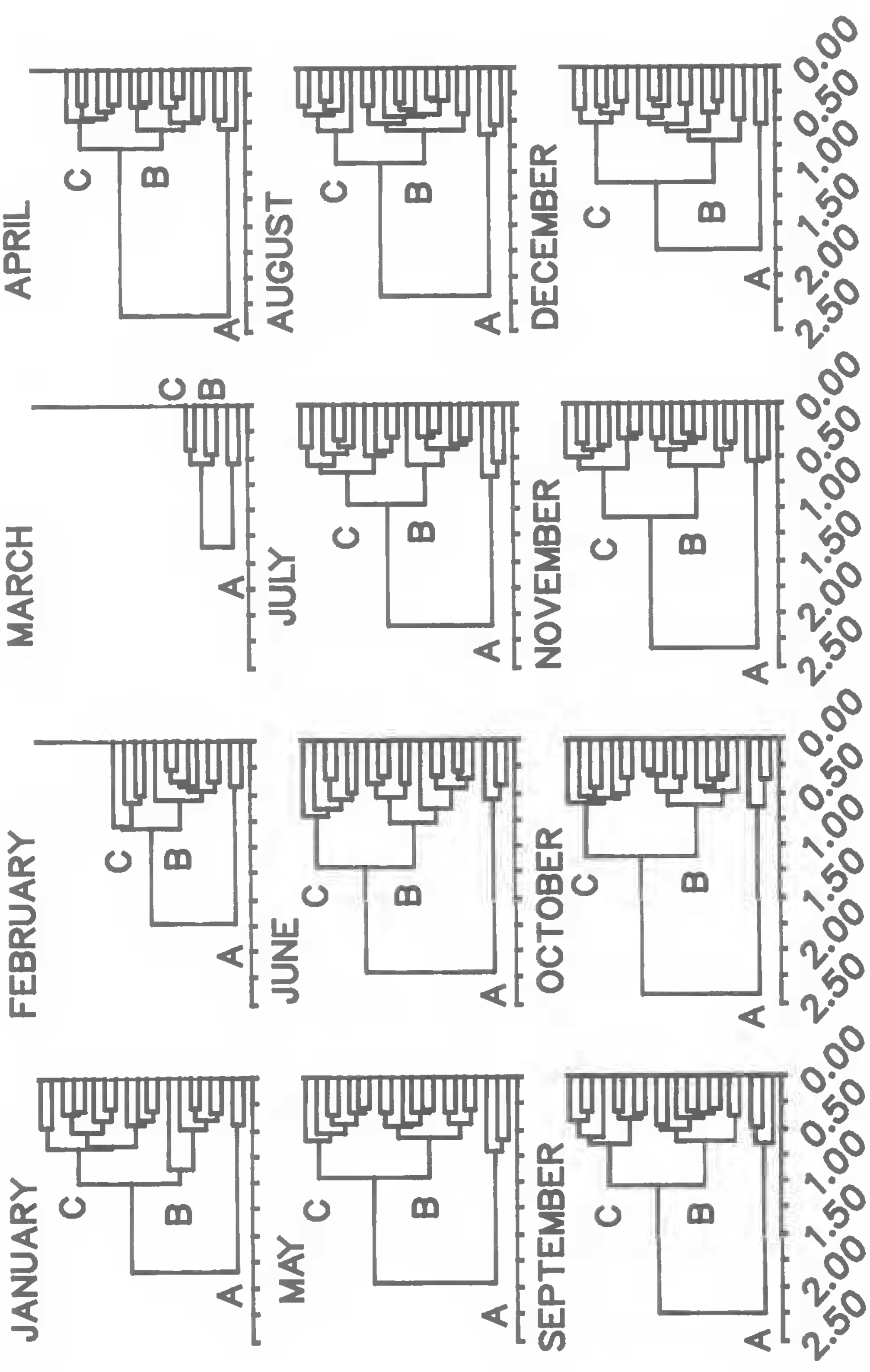

FIG. 2. Monthly dendrograms showing site assemblages resulting from the cluster analysis of sites based on species abundance. Site assemblages: 'A' - coastal, 'B' - inshore, and 'C' - inter-reef. The horizontal axes are dissimilarity indices and the vertical axes are site numbers.

TABLE 1. Classification of samples and sites. The monthly, total and overall classification of sites into site assemblages 'A' coastal, 'B' inshore , 'C' inter-reef, and those 'transitional' (indicated as B/C). Percent total occurrence appears in parentheses. Overall site assemblage classification and classification based on sediment analysis are included.

SITE	MONTH OF SAMPLE												TOTAL SAMPLES CLASSIFIED AS			OVERALL CLASSIFICATION	SEDIMENT GROUP
	J	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*	*'A'*	*'B'*	*'C'*		
1	A	A	A	A	A	A	A	A	A	A	A	A	12 (100)	—	—	A	A
2	A	A	A	A	A	A	A	A	A	A	A	A	12 (100)	—	—	A	B
3	B	B	B	B	B	B	B	B	B	B	B	B	—	12 (100)	—	B	B
4	B	B	B	C	B	B	C	B	C	C	B	C	—	7 (58)	5 (42)	B/C	B
5	C	—	C	C	C	C	C	C	C	C	C	C	—	—	11 (100)	C	C
6	C	C	C	C	C	C	C	B	C	C	C	C	—	1 (8)	11 (92)	C	C
7	C	B	—	B	B	B	C	C	C	C	C	B	—	5 (45)	6 (55)	B/C	C
8	C	C	—	C	C	C	C	C	C	C	C	C	—	—	11 (100)	C	C
9	B	B	—	C	C	C	C	C	C	C	C	B	—	3 (27)	8 (73)	C	C
10	B	C	—	C	C	C	C	C	C	C	C	C	—	1 (9)	10 (91)	C	C
11	C	—	—	B	C	C	C	C	C	C	C	C	—	1 (10)	9 (90)	C	C
12	B	B	—	B	B	B	B	B	B	B	B	B	—	11 (100)	—	B	B
13	B	B	—	B	B	B	B	B	B	B	B	B	—	11 (100)	—	B	C
14	B	B	—	B	B	B	B	B	B	B	B	B	—	11 (100)	—	B	B
15	B	C	—	A	A	A	A	A	A	A	A	—	8 (80)	1 (10)	1 (10)	A	A
16	C	—	—	B	C	B	C	B	B	B	B	B	—	7 (70)	3 (30)	B/C	B
17	C	—	—	B	B	B	C	B	B	B	C	B	—	7 (70)	3 (30)	B/C	C
18	C	—	—	—	B	B	B	B	B	B	B	B	—	8 (89)	1 (11)	B	C
19	C	—	—	—	B	B	B	B	B	B	B	B	—	8 (89)	1 (11)	B	C
20	C	—	—	—	B	B	B	B	B	B	B	B	—	8 (89)	1 (11)	B	B
	20	13	6	17	20	20	20	20	20	20	20	19	32 (15)	102 (47)	81 (38)		
	TOTAL SAMPLES IN MONTH																

ranked in order of their frequency of appearance on monthly lists. Only those which were listed as inherent at that site assemblage for five or more months appear in Table 2. The site assemblages can be characterized by those species that were missing. Table 3 ranks species that were missing from each site assemblage in five or more monthly samples.

From Table 3 we note that only *Orbonymus rameus* was common to lists of missing species from assemblages 'A' and 'C' and that only *Amusium pleuronectes* was common to lists of missing species from assemblages 'B' and 'C'. *Upeneus* sp. 1 was missing from assemblage 'A' throughout the entire 12 month sampling period.

Assemblage 'A' had noticeably more species missing (20) from five or more sample months during the study than did assemblages 'B' (5) or 'C' (9)(Table 3). Species common to 'B' and 'C' were often missing from 'A' which contributed to the greater dissimilarity of 'A' in classification analysis (Fig. 2). This should not, however, be confused with species richness; of the nearly 200 species included in the analysis, 82% occurred in site assemblage 'A' compared with 80% for 'B' and 70% for 'C', even though the latter two contained double the number of sites.

Commercially valuable animals, though possibly present, were generally not inherent to any site assemblage on a regular basis. The scallop, *Amusium pleuronectes*, was inherent in site assemblage 'A' for nine of the 12 months. By comparison the coral prawn, *Metapenaeopsis palmensis*, was inherent for only five months, and the brown and grooved tiger prawns, *Penaeus esculentus* and *P. semisulcatus*, were inherent for

TABLE 2. Inherent species characterizing site assemblages based on and ranked by the number of times they were inherent in five or more monthly samples. Parentheses enclose the number of months in which the species was inherent at that site assemblage. Taxa are represented by (B) Bivalvia, (C) Cephalopoda, (M)Malacostraca (Crustacea), and (O) Osteichthyes.

Assemblage 'A'	Assemblage 'B'	Assemblage 'C'
B *Amusium pleuronectes* (9)	M *Portunus rubromarginatus* (11)	M *Portunus argentatus* (9)
M *Charybdis truncata* (9)	O *Hypodytes carinatus* (9)	O *Nemipterus c.f. marginatus* (9)
O *Apogon poecilopterus* (7)	O *Parapercis nebulosa* (9)	O *Saurida undosquamis* (7)
O *Repomuscenus belcheri* (7)	O *Engyprosopon grandisquama* (8)	O *Trachinocephalus myops* (7)
M *Portunus pelagicus* (6)	O *Paramonacanthus japonicus* (6)	O *Upeneus* sp. 1 (5)
M *Metapenaeopsis palmensis* (5)	C *Sepia* spp. (6)	
O *Nemipterus hexodon* (5)	O *Dactyloptena papilio* (5)	
O *Priacanthus tayenus* (5)	O *Synodus similis* (5)	
O *Terapon theraps* (5)	O *Torquigener tuberculiferus* (5)	

TABLE 3 Missing species characterizing site assemblages based on and ranked by the number of times they were absent from five or more monthly samples. Parentheses enclose the number of months in which the species was missing from that site assemblage. Taxa are represented by (A) Ascidiacea, (B) Bivalvia, (C) Cephalopoda, (E) Echinoidea, (M) Malacostraca (Crustacea), and (O) Osteichthyes.

Assemblage 'A'	Assemblage 'B'
O *Upeneus* sp.1 (12)	B *Amusium pleuronectes* (9)
M *Penaeus longistylus* (11)	M *Charybdis truncata* (7)
O *Trachinocephalus myops* (11)	O *Priacanthus tayenus* (6)
O *Synodus similis* (10)	O *Arnoglossus waitei* (5)
E *Maretia planulata* (9)	O *Nemipterus hexodon* (5)
O *Sorsogonia tuberculata* (9)	M *Penaeus semisulcatus* (5)
O *Lepidotrigla calodactyla* (8)	
O *Nemipterus celebicus* (8)	
B *Amusium balloti* (7)	
O *Hypodytes carinatus* (7)	**Assemblage 'C'**
O *Parapercis nebulosa* (7)	
O *Inimicus caledonicus* (6)	O *Dactylopus dactylopus* (7)
O *Pseudorhombus dupliciocellatus* (6)	B *Amusium pleuronectes* (5)
A *Zooanthus* sp. 1 (6)	O *Apogon poecilopterus* (5)
O *Calliurichthys grossi* (5)	M *Charybdis jaubertensis* (5)
O *Choerodon* sp. 1 (5)	O *Lethrinus nematacanthus* (5)
O *Orbonymus rameus* (5)	M *Metapenaeopsis lamellata* (5)
M *Portunus tenuipes* (5)	O *Orbonymus rameus* (5)
O *Synodus sageneus* (5)	O *Repomuscenus belcheri* (5)
O *Torquigener tuberculiferus* (5)	E *Temnotrema bothryoides* (5)

four months. The commercial species, red-spot king prawns, *P. longistylus*, and the scallop, *A. balloti*, were inherent to site assemblage 'C' during only four of the 12 months sampled. Assemblage 'B' contained no currently commercial species which were consistently inherent.

There was a significant difference (chi-square, $p<.05$) in the proportions of samples taken from 'transitional' sites (Table 1) classified as 'B' and those classified as 'C' during the 'wet' season months (Feb-Jun) (87% 'B' and 13% 'C') compared with those taken during the 'dry' season months (Jan, Jul-Dec) (46% 'B' and 54% 'C'). There were, however, no significant (chi-square) differences in the proportions of other sites classified as 'A', 'B' or 'C' between the 'dry' and the 'wet' seasons.

Sediment Grain Size

Cluster analysis of the grain size composition of the sediments at each sampling site produced the dendrogram shown in Fig. 3. By choosing the same dissimilarity level (0.75) that was used to differentiate species assemblages based on species abundance, the sediment analysis also separated the sites into three major groups. There is a 75% overlap between the distribution of the sites among the site assemblages based on sediment composition and those based on species abundance (Table 1). The inclusion or exclusion of the transitional

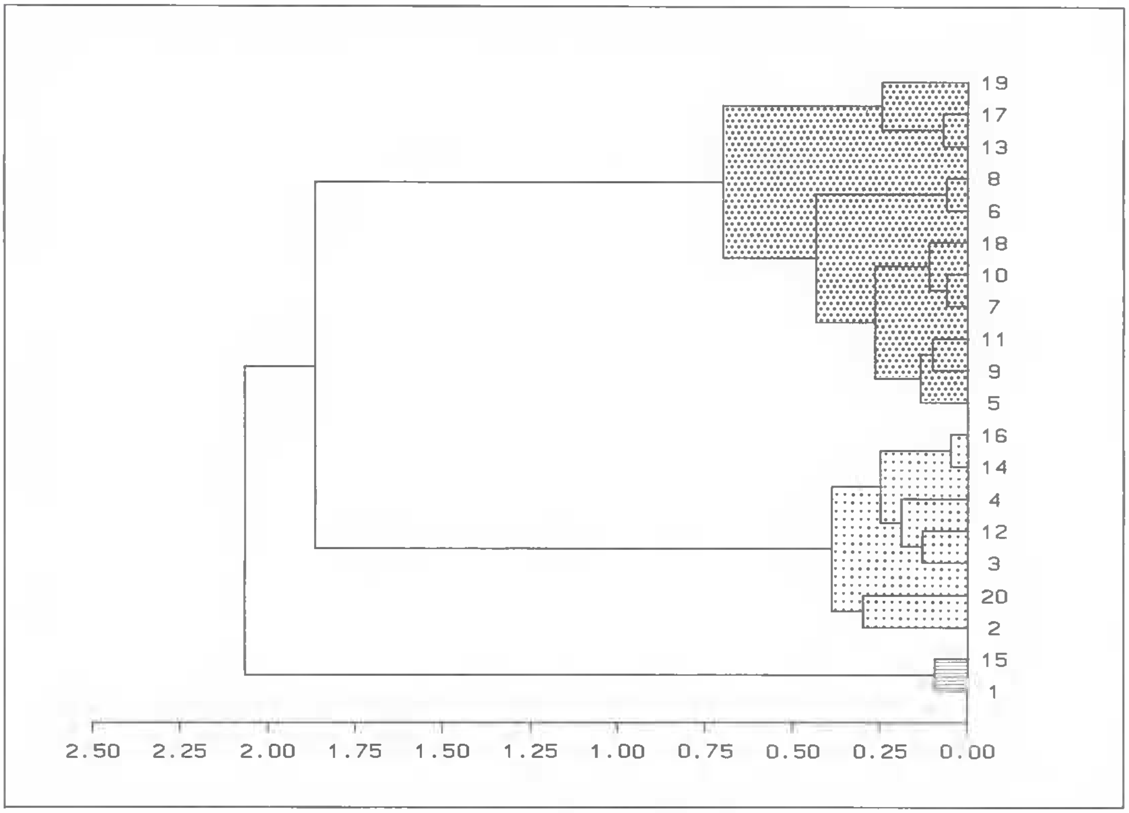

FIG. 3. Dendrogram resulting from cluster analysis of sites based on sediment particle size distribution. Site assemblage affiliations: 'A' - coastal (strips), 'B' - inshore (small dots), and 'C' - inter-reef (large dots). The horizontal axis is the dissimilarity index and the vertical axis are site numbers.

sites had no effect on the level of overlap when they were ranked according to their most common species assemblage affiliations.

Fig. 4 shows the distribution of grain sizes among the three site assemblages. The 'coastal' assemblage ('A') was characterized by fine mud (<0.063 mm), the 'inshore' assemblage ('B') by coarser sediments (1-0.125 mm), and the 'inter-reef' assemblage by fine sediments ranging down to mud (0.25-<0.063 mm). Sediments at the transitional sites were the same as those of the 'inshore' assemblage.

Sediment Carbonate Levels

Maxwell (1968) described the general distribution of carbonate sediment for much of the GBR region. Sediment with high carbonate levels (80%-100%) was considered to be reefal in origin while sediment with low carbonate levels (20% - 40%) was considered to be terrigenous. Using Maxwell's (1968) sediment distributions and classifications, the site assemblages based on species

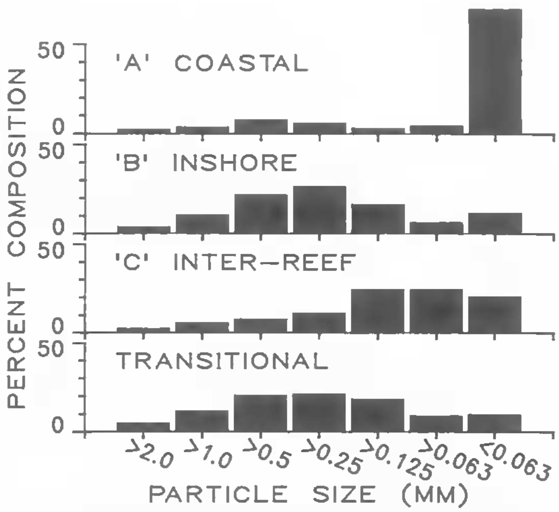

FIG. 4. Distribution of sediment particle sizes within site assemblages: 'A' - coastal, 'B' - inshore, 'C' - inter-reef and, transitional.

abundance separate out well according to carbonate content (Table 4).

Depth Of Trawl Site

The site assemblages could also be separated according to the depth of each sampling site (Table 5). Percentage overlap in the distribution of sites grouped with the 'inshore' assemblage versus the 'inter-reef' assemblage based on sediment types (Table 4), and that based on depth ranges (Table 5) was the same with the transitional assemblages omitted (14%), as it was with the transitional assemblages distributed between 'inshore' and 'inter-reef' assemblages according to their strongest affiliation (20%).

Fishing Effort

In general the average commercial trawling hours recorded from logbook grid areas containing study sites was low during the 1984-85 period (Table 6). The average fishing efforts for 84/85 on the 'inshore' and 'inter-reef' assemblages were similar. This was 5-6 times that of the 'coastal' assemblage but only half that recorded for sites in the transitional assemblage (Table 6).

DISCUSSION

Our results showed three distinct site assemblages based on species abundance. Because each site demonstrated considerable variability in species abundances from one monthly sample to the next, consistency of classification was obtained at higher levels of dissimilarity, that is, at broader levels of community description.

The occurrence and distribution of these three zones supports the work of Cannon *et al.* (1987) who used extensive trawling techniques over most of the GBR region. Their work covered a total of 229 essentially random sites from which approximately 700 species were collected. Each site was, however, sampled only once and thus temporal trends could not be investigated. Similarly, Rainer

TABLE 4. The carbonate content of sample sites within the site assemblages. Numbers are the numbers of sites.

% Carbonate	Number of Sites in Site Assemblage			
(after Maxwell, 1968)	'Coastal'	'Inshore'	'Transitional'	'Inter-Reef'
0-20	—	—	—	—
20-40	3	—	—	—
40-60	—	—	—	—
60-80	—	6	2	—
80-100	—	1	2	6

TABLE 5. The depth range of sample sites within the site assemblages. Numbers are the numbers of sites.

Depth Range	Number of Sites in Site Assemblage			
(depth in m)	'Coastal'	'Inshore'	'Transitional'	'Inter-Reef'
0-12	—	—	—	—
13-24	3	—	—	—
25-36	—	2	—	—
37-48	—	4	2	—
49-60	—	1	2	6

TABLE 6. Average monthly commercial fishing effort from site assemblage sites in hours per grid area from those 6' by 6' grids that included sample sites. Percentage of monthly average effort from each site assemblage is shown in parentheses. Data from 1984 covers the period August to December only.

Site Assemblage		Monthly Commercial Fishing Effort (h)		
		1984	1985	Average 84/85
Coastal	A	0.67 (2.4)	1.25 (6.2)	0.96 (4.0)
Inshore	B	1.70 (6.1)	10.36 (51.7)	6.03 (25.2)
Inter-reef	C	7.04 (25.3)	2.11 (10.5)	4.58 (19.1)
Transitional		18.39 (66.2)	6.32 (31.6)	12.36 (51.7)
Total		27.80	20.04	23.93

and Munro (1982) found broad zones paralleling the coast in the Gulf of Carpentaria and concluded that there were distinct inshore and offshore species assemblages.

We were able to characterize each zone in the central GBR by the conspicuous abundance or absence of particular species. Lists of species missing from each zone were not indicative of species richness but of faunal similarity. More of the species recorded from the study area were found at the 'coastal' site assemblage than at the 'inshore' or 'inter-reef' assemblages even though the 'coastal' assemblage had more conspicuously missing species then the latter two assemblages.

Though the distribution of commercial fishing effort prior to and during this study may be associated with the differences in the rank order of some species between the 'coastal' site assemblages and those further offshore, it fails to explain the differences between the 'inshore' and 'inter-reef' site assemblages, which recorded variable but similar overall fishing effort. Differences in fishing effort distribution do not explain why the 'transitional' sites, which had more than double the fishing effort of the 'inshore' and 'inter-reef' sites, clustered monthly with either the 'inshore' or 'inter-reef' sites. It is possible that the greater fishing effort expended at 'transitional' sites may have influenced the seasonal changes in species abundance which caused these sites to change affinity between the 'inshore' and 'inter-reef' assemblages from month to month. The presence and distribution of the site assemblages can be more readily linked, however, with depth and sediment composition than with the distribution of fishing effort.

The results of our study suggest that both temporal and physical factors play a role in establishing the distribution of species assemblages. We found that sediment and depth were equally related to the species zonation pattern but speculate that sediment may be more important in determining the distribution of demersal and benthic organisms. Penaeid prawn distribution is influenced by both sediment composition and depth in northern Australia (Somers, 1987).

Individual species may well react to summer/winter changes through an extension or contraction of range, but there was only minimal evidence to support the phenomenon at the assemblage level. There was, however, a shift of assemblage boundaries (the 'transitional' sites) which could be related to the wet and dry seasons of the Queensland tropical coast. It must be kept in mind that only about 20% of the sites were classified as 'transitional' and so the effect must be viewed as very weak relative to that of depth and sediment type.

Rainer (1984) concluded that trawled communities in the Gulf of Carpentaria were basically depth-related but did show some seasonal shift to deeper regions in September compared with March. Rainer (1984) concluded that his 1960s data portrayed a fish and cephalopod community in continual flux. Further research trawling in 1983 (Poiner and Harris, 1985), after 20 years of exposure to commercial fishing, revealed that 'the site groups for each month . . . conform reasonably well with the patterns (inshore and offshore) detected by Rainer (1984)'. Extensive trawling within the GBR region led Cannon *et al.* (1987) to conclude from the agreement between their data and both Gulf studies that 'the inshore/offshore pattern is a stable one despite slight seasonal changes or others created by the advent of commercial trawling'.

Three site assemblages: coastal, inshore and inter-reef could be characterized by bycatch species. In our study most of the species occurred at some time in each site assemblage and no species were present throughout the whole year. The collection of species that defined each site varied; but the grouping of sites that defined the assemblages remained relatively constant. Thus the assemblages, although reasonably consistent in structure, are characterized by their dynamic nature and by flexible boundaries that move as the fauna responds to subtle environmental changes or move to meet their particular life-cycle requirements. They do not seem to have the rigidity that would be maintained through the slower acting effects of inter-specific competition.

Future work could make more detailed study of representative sites from the three site assemblages to determine the scale of inter-annual variation and to monitor any changes induced to benthic substrates and benthic community structure by commercial trawling.

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